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April 4, 1995

BY HAND DELIVERY

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W.
Washington, D.C. 20554

EX PARTE OR LATE FILED

Re: Ex Parte Presentation
CC Docket No. 92-297

Dear Mr. Caton:

Enclosed for filing on behalf of Teledesic Corporation ("Teledesic") in the above-captioned proceeding is Teledesic's study entitled "Optimistic" Antenna Sidelobe Patterns Do Not Solve the Interference Problem Between FSS and LMDS, (Oct. 1994) ("FSS and LMDS Interference Study"). Teledesic has previously filed the FSS and LMDS Interference Study with the Federal Communications Commission in connection with another matter and is filing it in the above-referenced proceeding for purposes of a complete and accurate record in response to Scott Seidel's paper, Interference from FSS Uplinks into LMDS Receivers: The Impact of Improved Antenna Patterns contained in the Report of the LMDS/FSS 28 GHz Band Negotiated Rulemaking Committee, CC Docket No. 92-297 (Sept. 23, 1994).

Pursuant to Section 1.1206(a)(1) of the Commission's Rules, an original and two copies of this letter and its attachments are enclosed.

Very truly yours,

Tom W. Davidson, P.C.
Jennifer A. Manner

"Optimistic" Antenna Sidelobe Patterns Do Not Solve the Interference Problem Between FSS and LMDS

Prepared by

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October 1994

TP-3004-94080

Teledesic

"Optimistic" Antenna Sidelobe Patterns Do Not Solve the Interference Problem Between FSS and LMDS

1. Summary

The purpose of this paper is to provide constructive comments on the paper entitled "Interference from FSS Uplink into LMDS Receivers: The Impact of Improved Antenna Patterns" by Dr. Scott Y. Seidel of Bell Communications Research. The paper by Dr. Seidel is based on the assumption that the Teledesic Standard Terminal (TST) can achieve large antenna sidelobe discrimination. He justifies this assumption based on a one page comment paper entitled "Comments Concerning Earth Station Interference Predictions" by Geza Dienes from Andrew Corporation. In this paper Dienes states that **theoretical** improvements to the antenna sidelobe pattern **may be** possible. Dienes does not describe any practical implementation nor does he address the cost of the antenna. In the Appendix to this paper it is clearly shown that **the improvements in antenna patterns cited by Dienes are neither achievable nor economically feasible. Hence the basis on which Dr. Seidel analysis is built is not valid.**

Dr. Seidel himself also acknowledges that the antenna sidelobe discriminations may not be either "realizable" or "economically viable". After this disclaimer, Dr. Seidel then engages in an academic exercise, calculating the interference distances between a single LMDS receiver and a TST. He then shows that reducing the antenna sidelobes of a TST results in a decrease of the required separation between an LMDS receiver and a Teledesic terminal. Claiming partial victory in interference mitigation, Dr. Seidel then reaches out for other mitigation factors, calling them "real world" factors to magically solve the remaining interference problems, ignoring the fact that all these mitigation factors were considered before and were found to be ineffective or inadequate.

Dr. Seidel's paper is a simplistic analysis which only considers the interference between a single LMDS receiver and the TST. **Dr. Seidel fails to analyze the overall interference scenario within each LMDS cell.** This paper follows the comprehensive analysis method which is used in the final report to the LMDS/FSS 28 GHz Band Negotiated Rulemaking Committee from Working Group 1. **The analysis in this paper clearly shows that even with the "optimistic" antenna sidelobe assumptions, the interference between the LMDS and FSS is severe and that frequency sharing is not possible.** This paper also examines the "real world" factors that Dr. Seidel claims were not considered during the NRMC, and shows that these techniques were discussed extensively and none was shown to be effective or adequate.

2. The Interference Analysis

The analysis performed by Dr. Seidel is based on the TST achieving large antenna sidelobe discriminations. Dr. Seidel acknowledges that these antenna sidelobe discriminations may not be either "realizable" or "economically viable". He then bases his analysis on the assumption that these sidelobe levels can be achieved. Clearly **technical and economic feasibility are crucial to determining the applicability of any approach and with out them the analysis is just an academic exercise.** In his paper, Dr. Seidel denotes the new antenna discrimination values as "a conservative improvement" for 63-dB of sidelobe discrimination and as "an optimistic improvement" for 78 dB of sidelobe discrimination. Perhaps, better annotations would be "optimistic improvement" and "unrealistic improvement".

The Bellcore paper refers to the Andrew Corporation submission NRMC-104 wherein "theoretical" antenna improvements of 20-45 dB are indicated. No specific techniques are identified. No engineering sketches are given and no cost estimates are provided. In the Appendix to this paper it is clearly shown that antenna sidelobe improvements cited cannot be achieved.

Figures 6.2-1 and 6.2-17 of the Working Group 1 (WG1) report show the interference calculations based on the parameters that were provided by the system proponents. For the clear sky condition these values match the values that are given in Table 1 of Dr. Seidel's paper. Dr. Seidel calculates the interference under rain conditions in a slightly different manner assuming that the maximum rain cell size is 4 km. Hence, the results presented in the paper for the rain condition (first column of Table 3) are much worse than the results shown in Figure 6.2-1 of the WG1 report.

Figure 6.2-17 illustrate the percentage of the LMDS cell area unavailable for use by a TST as a function of the number of LMDS receivers within that particular cell. This plot is calculated by generalizing the analyses results from Figure 6.2-1. Multiple LMDS receivers are randomly placed throughout the LMDS cell. For each given number of LMDS receivers and their placement, cell area availability is calculated by determining those areas of the cell in which the Teledesic Standard Terminal can operate without causing any LMDS hub to subscriber link C/(N+I) to fall below its minimum acceptable interference value. The cell area availability is calculated under both clear sky and heavy rain conditions. **Figure 6.2-17 shows that the cell area availability for use by a TST diminishes to less than 20% of the cell when there are only 20 LMDS receivers present under either clear sky or heavy rain conditions. The fact that the average number of subscribers that CellularVision plans to have in each cell is 7800 illustrates the magnitude of the interference problem.** It should also be noted that although the interference zone from a single LMDS subscriber covers many LMDS cells, in calculating the cell available area, the interference from adjacent cells is not taken into account. If interference zones from adjacent cells are considered, the cell availability area will decrease even further.

Figures 1 and 2 show the interference zone for a single LMDS receiver under the sidelobe discrimination levels specified by the paper. The results shown in these figures match the results of Table 2 of the paper. From these figures, it can be seen that the interference zone has been decreased as a result of the new optimistic and unproven antenna sidelobe discrimination values. However, even in these cases, the presence of a single LMDS receiver results in a substantial interference zone within which the TST cannot operate. For example in the case of "conservative improvement" (63 dB antenna sidelobe discrimination), the presence of just a **single** LMDS receiver produces an interference zone which covers 0.47 percent and 3.6 percent of the LMDS cell area under clear sky and heavy rain conditions, respectively. **Dr. Seidel's results presented in Table 3 of his paper are not very encouraging either. Under the condition of "optimistic improvement", a single LMDS receiver produces an interference zone that extends for 1 mile along its antenna boresight and for 0.25 miles at its 5 degree antenna sidelobe.**

Figures 3 and 4 show the available cell area as a function of LMDS subscribers. In these cases the cell availability decreases more gradually as the number of LMDS subscribers is increased. However, the conclusions remain the same. **For the projected number of LMDS subscribers per cell, the cell availability for FSS earth stations is extremely limited (almost nonexistent).** Even in the case of the "Optimistic Improvement" the cell availability is less than 20% with only 3000 subscribers. In other words even if FSS earth stations could somehow achieve the conditions of "optimistic improvement", LMDS and FSS cannot share the same frequencies.

The problem with Dr. Seidel's analysis is that he only considers a single LMDS receiver at a fixed location. By contrast, the analyses presented in the WG1 report takes into consideration the location of each subscriber relative to the cell center as well as the effect of operation of a number of the subscribers in each cell. **In short the analysis presented by Dr. Seidel in his paper is both "optimistic" and "unrealistic".**

3. The Additional Mitigation Factors

Dr. Seidel realizes that even with the "Optimistic" antenna sidelobe discrimination values the interference problem between FSS and LMDS cannot be solved. Therefore he claims only partial success and points out that using the sidelobe discrimination the interference zone has been reduced significantly and that now it is the job of the "real-world", as he puts it, to take care of the remaining interference problems. Dr. Seidel then reaches out for any qualitative argument which will somehow solve the interference problem. No quantitative analysis is given in Section 5 of the paper. It is argued that there exists "real-world" factors that are unfavorable to the interfering signals and are favorable or neutral to the LMDS transmitted signals. In what follows short responses to these special interference mitigation factors are given. The sentences in *Italic* are the mitigation factors identified by Dr. Seidel in his paper.

1. *FSS earth station antennas are not always azimuthally pointed toward the LMDS receivers.*
As Dr. Seidel points out it is appropriate to assume that the FSS earth station antennas are pointing in the direction of LMDS receivers with elevation angles of greater than 40°, since this scenario occurs in the "real world" operation of the systems. However, Dr. Seidel points out that the direction of the FSS earth station antenna change as function of time and hence different LMDS receivers will be impacted.

It is not clear how this "real world" mitigation factor will help the interference scenario. The FSS earth stations will point "over the head" of different set of LMDS receivers at each instant of time, but the fact remains that it will point "over the head" of most of the LMDS receivers over time. More importantly Dr. Seidel fails to note that the antenna discrimination of the FSS earth station does not improve appreciably even if the FSS earth station antennas are not azimuthally pointed towards the LMDS receivers. This is especially true if one has been able to build antennas with sidelobe discrimination levels of "Conservative Improvement" or "Optimistic Improvement".

2. *FSS earth station antenna elevation angles are often greater than 30-40 degrees.*
In calculating the interference from FSS earth stations to the LMDS receivers, it is assumed that the minimum elevation angle of the FSS earth stations is 40 degrees. In the Teledesic system, the antenna sidelobe discrimination of the TST does not decrease appreciably for elevation angles above 40 degrees. In other words, for TSTs the 40 degree antenna sidelobe discrimination is close to the antenna discrimination for the backlobe.

3. *FSS earth station may be located higher than the LMDS antennas, leading to increased angular discrimination.*
As it is described above, increased angular discrimination does not translate to additional antenna sidelobe discrimination. It is interesting that Dr. Seidel still looks to achieve further antenna sidelobe discrimination by increasing the angular discrimination. Specially since Dr. Seidel admits that the antenna sidelobe discrimination levels of "Conservative Improvement", and Optimistic Improvement" that he used for purpose of his interference analysis may not be feasible,. Dr. Seidel indicates in Section 6 that FSS earth stations may also be located lower than or at the same level as the LMDS antenna, which can potentially result in increased levels of interference.

4. *FSS earth stations will not often be at maximum output power, and will only do so only under heavy rain condition*
The argument is not very clear but it seems to imply that FSS earth stations really do not need to provide service under heavy rain conditions. This argument more likely reflects the Dr. Seidel's disappointment with his interference results under heavy rain conditions. Clearly FSS and LMDS are designed to operate both in clear sky and heavy rain conditions. Therefore, the interference between LMDS and FSS with rain should be considered as an integral part of the interference analysis and should not be something that can be ignored if the interference results are not desirable. In any case, the analysis in this paper as well as in the Working Group 1 report shows clearly that the interference in the clear sky condition is severe and does allow frequency sharing between LMDS and FSS.

5. *FSS earth stations will not always be transmitting.*
It is true that FSS earth stations do not transmit at all times. However the relevance of this factor is not clear. The analysis above shows that FSS earth stations cannot transmit during any period of time without causing severe interference to LMDS.

6. *FSS earth station transmissions may be bursty with a low (~10%) duty cycle.*
Tests performed by the WG1 showed that analog signals cannot tolerate 10% duty cycle interference. Time sharing with digital systems based on inter-system synchronization was proposed and LMDS proponents concluded that it is not feasible based on current technology.

7. *FSS earth stations transmitting at T1 rates only interface with a small number of LMDS video channels. Hence, for analog video, perceived interference may be less than actual interference situation.*
Although the interference calculations were performed with only one T1 user within the bandwidth of an FM receiver, a similar interference situation exists if several lower data rate users interfere with a single FM receiver. Dr. Seidel suggests that the FSS earth stations may interfere with a TV channel that the subscriber is not watching. Clearly, if the subscriber is not watching TV, then the interference from an FSS earth station does matter to him. However, LMDS proponents indicated during the working group discussions as well as at the committee meetings that once they provide a certain TV channel to the subscribers, they cannot tolerate interference to that channel. Furthermore, the Teledesic Network as well as the Spaceway system allocate channels dynamically every frame based on the traffic demand. Therefore, over time, a single FSS earth station can interfere with several LMDS channels.

8. *FSS uplink antennas may employ higher gain antennas.*
The interference is a function of transmitted EIRP and not the transmitter power. Therefore the use of higher gain antennas with lower transmitter powers does not

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reduce the interference. Dr. Seidel is correct in mentioning that it is easier to achieve sidelobe discrimination with higher gain antennas. However, the sidelobe levels indicated in the paper are still "Optimistic"

9. *In a typical operating environment, there will often be building and foliage blocking between FSS earth stations and LMDS receivers.*
Building and foliage blockage exists equally for the interfering signal as well as the desired signal. For example, foliage can reduce the power of the signal from the LMDS hub to the subscriber and hence reduce the C/(N+I) to make the interference situation worse. Natural or manmade blockages do not discriminate between the desired signal and the interfering signal. Hence it is equally likely that they can increase the interference impact.

10. *Many LMDS receivers will have received carrier levels greater than the level received at the cell edge.*
The Working Group report and the results presented here calculate the interference based on the exact location of the users. Only Dr. Seidel in his analysis assumes that the LMDS receivers are located at the cell edge.

11. *LMDS subscriber receivers may also be able to employ antennas with reduced sidelobe levels.*
CellurVision indicated, during the NRMC, that they do not believe that they can deploy antennas with reduced sidelobes economically.

The "real world" mitigation factors that Dr. Seidel presents in Section 5 of his paper basically can be divided into three categories. The first category, as amazing as it may sound, argues that additional sidelobe discrimination beyond the "Conservative Improvement" and "Optimistic Improvement" is possible ("real world" mitigation numbers 1, 2, 3, and 8). The second category only establish that the interference levels are not always the same. For example in heavy rain condition there is more interference than in clear sky condition. These factors will not solve the interference problem. The LMDS proponents very clearly stated during the NRMC that once they provide a service to a customer they cannot tolerate any interference to that channel at any time. In other words, they cannot say to their customers that you can watch the World Cup soccer final provided that it is not raining in your area, your neighbor is not using its Teledesic terminal, or there is big tree between your receiver and your neighbors terminal. ("real world" mitigation numbers 4, 5, and 9). The third category are factors that are not valid and do not reduce interference because they involve misconceptions by Dr. Seidel ('real world" mitigation numbers 6, 7, 10, and 11).

In Section 6 of his paper, Dr. Seidel introduces three factors that may increase the interference between LMDS and FSS. However, he then quickly argues against all these factors and, using the same familiar arguments that he used in Section 5, he concludes that these factors can really be considered as mitigation factors.

Despite Dr. Seidel's assertion that some of the mitigation techniques were not considered during the NRMC, all these techniques were discussed several times and none was shown to be effective or adequate.

4. The Conclusions

Dr. Seidel, in his paper, proposes antenna sidelobe discrimination levels for FSS without knowing if these levels are "realizable or economically viable". Based on these sidelobe discrimination factors, he concludes that the interference zones have been reduced. He fails to analyze the overall interference scenario within each LMDS cell which despite the improvement still does not allow sharing between LMDS and FSS. And finally, he reaches out for other mitigation factors to magically solve the remaining interference problem, ignoring the fact that all these mitigation factors were considered before and were found to be ineffective or inadequate. **The paper tries to portray the interference scenario between the LMDS and FSS in an "optimistic" and "unrealistic" manner and ignores the reality of the results of extensive analyses performed by the working groups of the NRMC which concluded that sharing between LMDS and FSS is not possible.**

Clear Sky | Rain

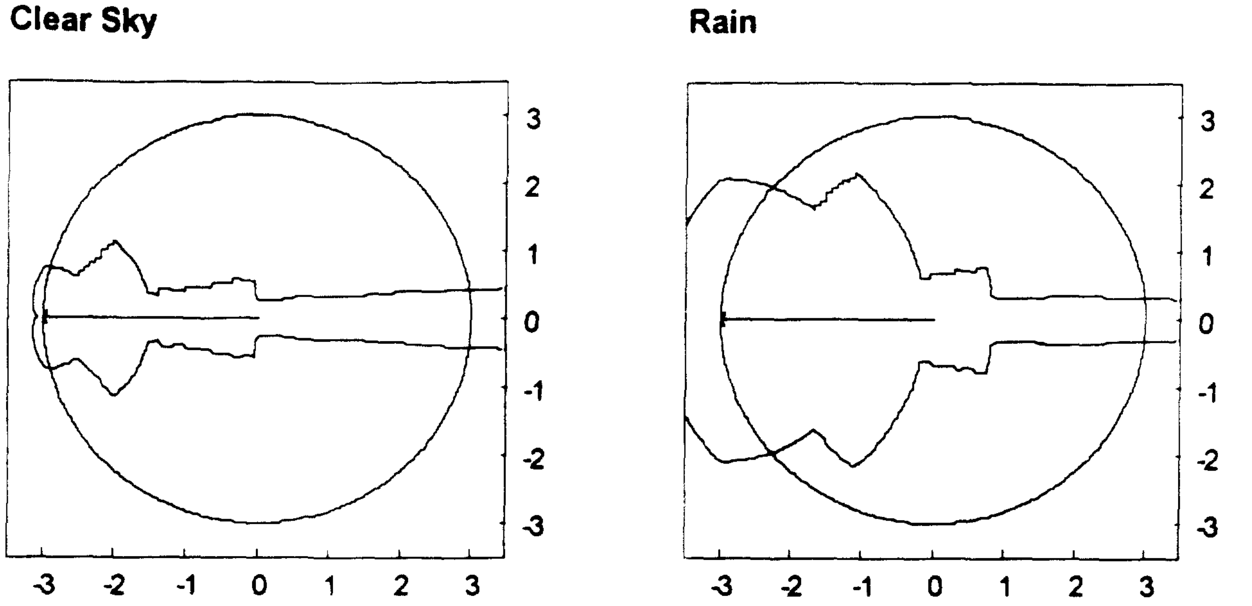

Figure 6.2-1 T1 TST into CellularVision hub-to-subscriber link.

Parameter Summary

	Desired	Interference
Cell Size (miles)	3.00	
Transmit Power (dBW)	-4.00	0.85
Power Increase in Rain (dB)	0.00	17.10
Transmit Antenna Peak Gain (dBi)	12.00	36.00
Signal Bandwidth (MHz)	18.00	26.50
Interference Antenna Elevation (deg)		40.00
Receive Antenna peak Gain (dBi)	31.00	
Noise Temperature (dB°K)	30.65	
Required C/(N+I) (dB)	26.00(13.00)	

Analysis Result

	Clear Sky	Rain
Boresight min. Clearance (mile)	23.7	8.00
Sidelobe (45°) min. Clearance (mile)	1.50	2.88
Backlobe min. Clearance (mile)	0.0751	0.494
Cell Availability (% of a cell)	79.7	57.7

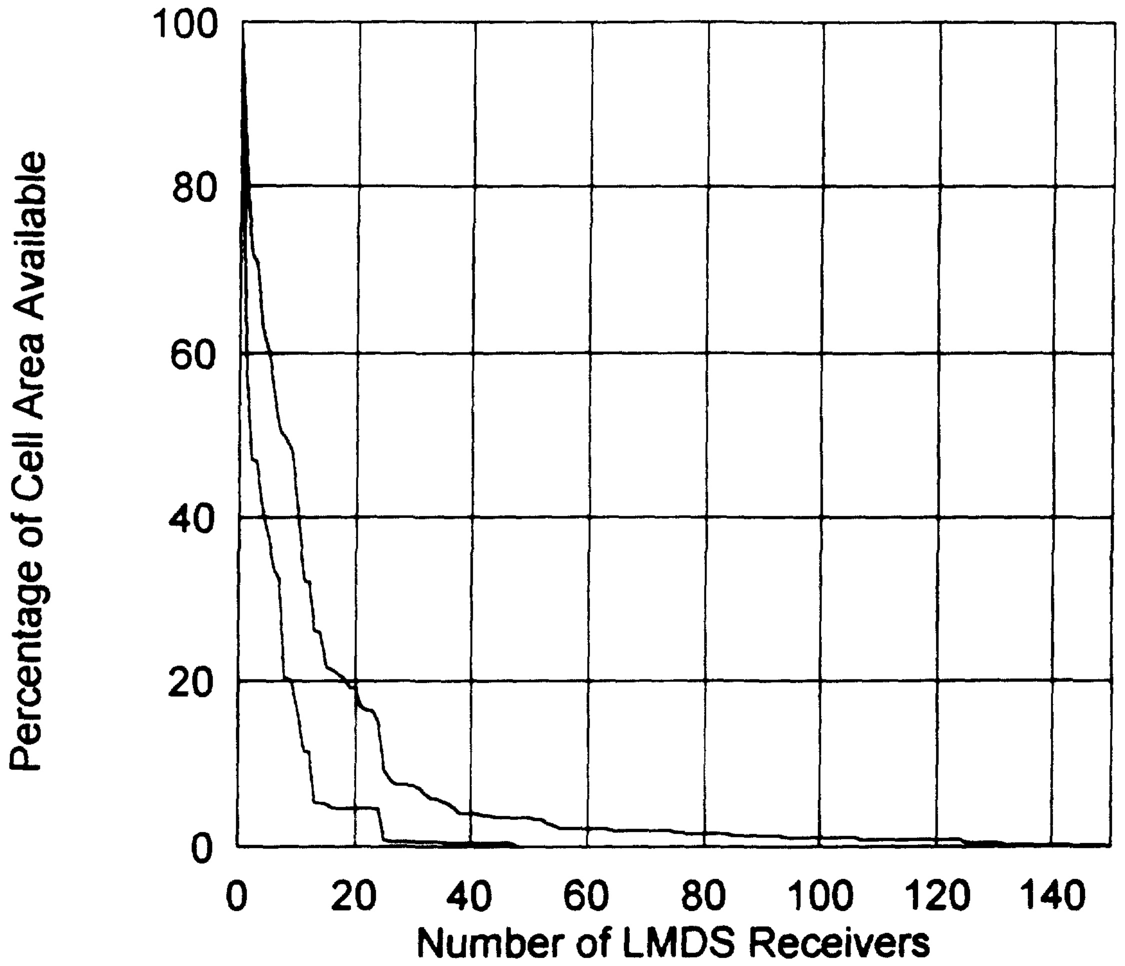

Figure 6.2-17 Percentage of CellularVision LMDS Cell Area where Teledesic can Operate TST without Interfering with LMDS Hub-to-Subscriber Link. The lower curve is computed in heavy rain condition and the upper curve is computed in clear sky condition.

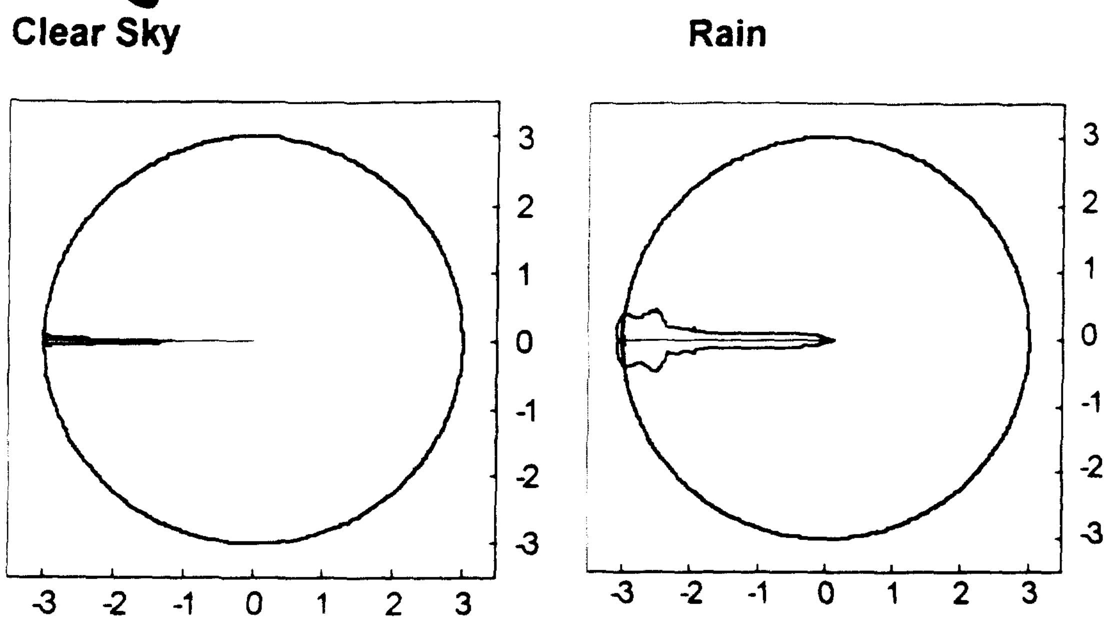

Figure 1. T1 TST into CellularVision hub-to-subscriber link.

Parameter Summary

	Desired	Interference
Cell Size (miles)	3.00	
Transmit Power (dBW)	-4.00	0.85
Power Increase in Rain (dB)	0.00	17.10
Transmit Antenna Peak Gain (dBi)	12.00	36.00
Signal Bandwidth (MHz)	18.00	26.50
Interference Antenna Sidelobe Discrimination (dB)		**63.00**
Receive Antenna peak Gain (dBi)	31.00	
Noise Temperature (dB°K)	30.65	
Required C/(N+I) (dB) (clear/rain)	26.00/13.00	

Analysis Result

	Clear Sky	Rain
Boresight min. Clearance (mile)	1.8	3.1
Sidelobe (45°) min. Clearance (mile)	0.11	0.67
Backlobe min. Clearance (mile)	0.0057	0.049
Cell Availability (% of a cell)	99.53	96.4

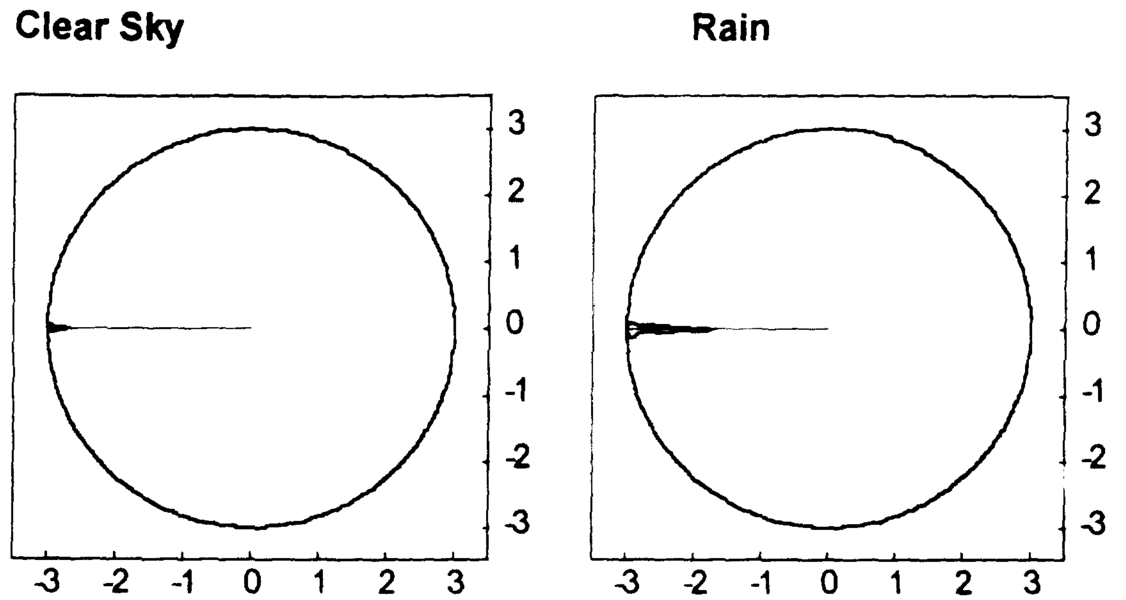

Figure 2. T1 TST into CellularVision hub-to-subscriber link.

Parameter Summary

	Desired	Interference
Cell Size (miles)	3.00	
Transmit Power (dBW)	-4.00	0.85
Power Increase in Rain (dB)	0.00	17.10
Transmit Antenna Peak Gain (dBi)	12.00	36.00
Signal Bandwidth (MHz)	18.00	26.50
Interference Antenna Sidelobe Discrimination (dB)		**78.00**
Receive Antenna peak Gain (dBi)	31.00	
Noise Temperature (dB°K)	30.65	
Required C/(N+I) (dB) (clear/rain)	26.00/13.00	

Analysis Result

	Clear Sky	Rain
Boresight min. Clearance (mile)	0.32	1.3
Sidelobe (45°) min. Clearance (mile)	0.020	0.16
Backlobe min. Clearance (mile)	0.0010	0.0090
Cell Availability (% of a cell)	99.931	99.62

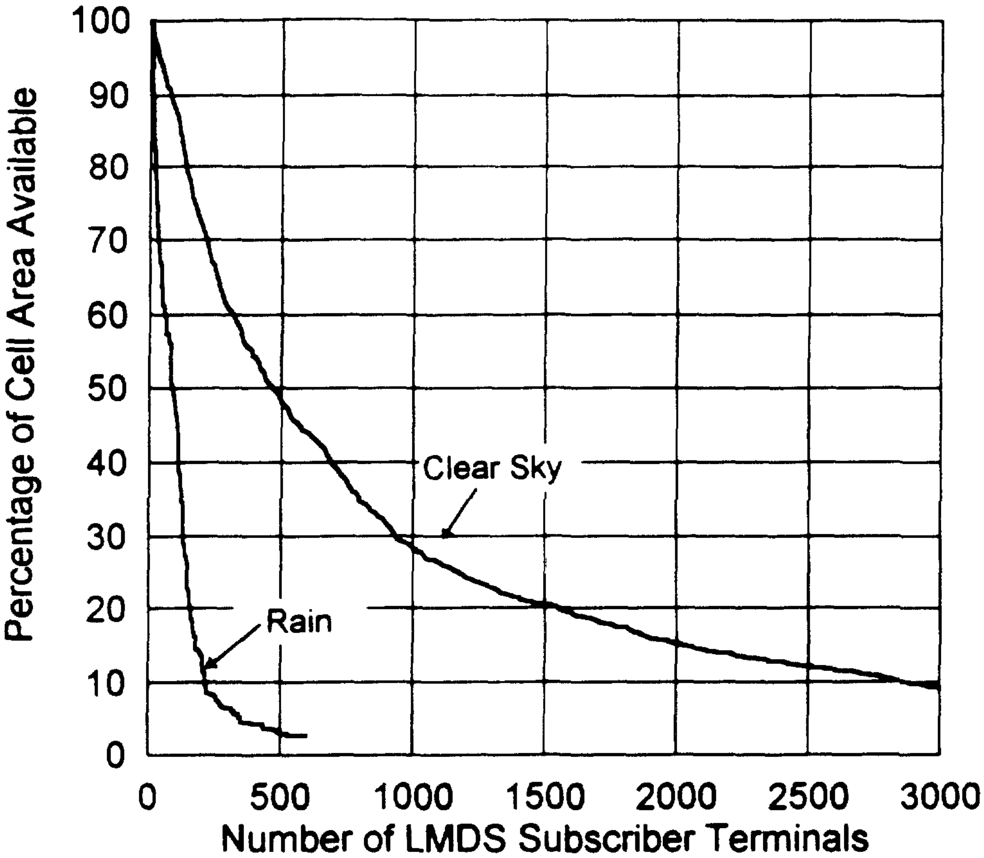

Figure 3. Percentage of Cellular Vision Cell Area Available for TST Operation for Minimum Sidelobe Discrimination of 63 dB.

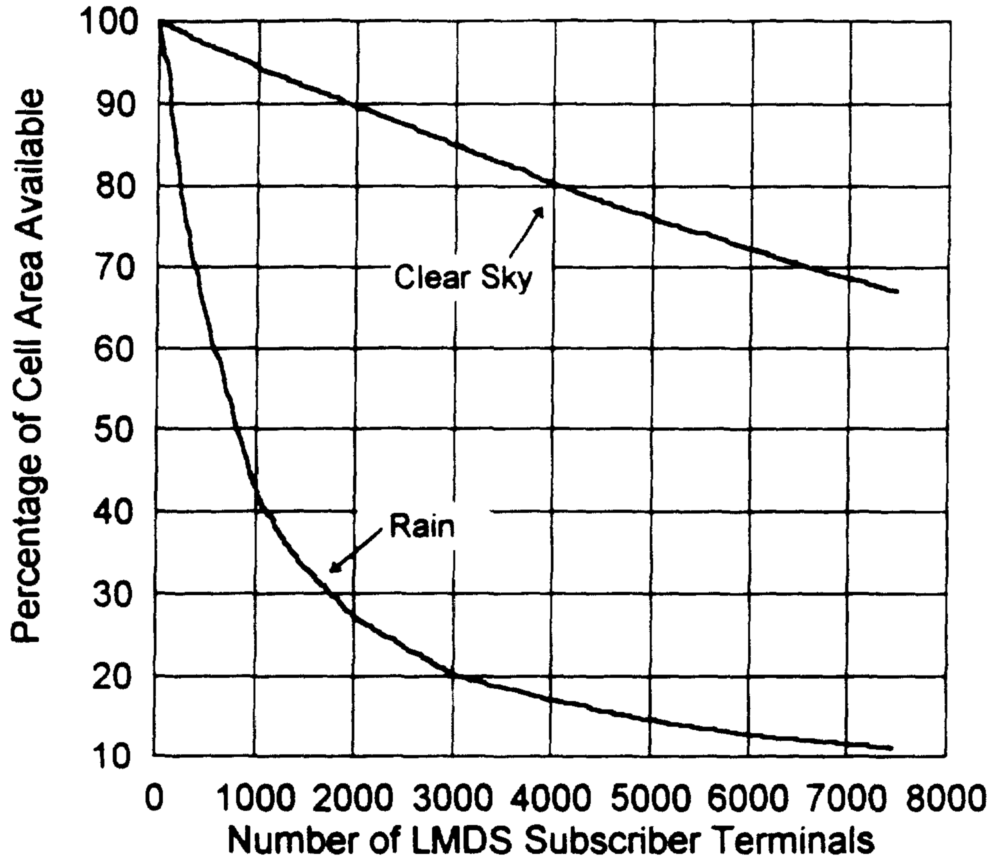

Figure 4. Percentage of Cellular Vision Cell Area Available for TST Operation for Minimum Sidelobe Discrimination of 78 dB.

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Appendix

The Improvements in Antenna Patterns Cited by Dienes Are Not Achievable

A Review of the Paper "Comments Concerning Earth Station to LMDS Interference Prediction" by Geza Dienes, Andrew Corporation[1].

The analysis in the final report to the LMDS/FSS 28 GHz Band Negotiating Rulemaking Committee from Working Group 1 was based on a -40 dB antenna sidelobe discrimination for TST ground terminals for angles beyond 40° from boresight. Dienes in his paper indicates that " ..... on a well designed aperture, we find that **theoretical** improvement approaches 38 - 45 dB. On a phased array the improvement **may be** limited to 20 - 25 dB." (emphasis added) In this appendix it is shown that the improvements claimed by Dienes are based on theory only and he does not consider the specification and requirements of the Teledesic Standard Terminals. It is further shown that these improvements are neither achievable nor economically feasible for Teledesic Standard Terminals.

If the TSTs use dish antenna with offset reflectors and enclosing tunnels, then indeed some improvement is possible for the terminals with the largest antenna diameters. The tunnels need to be at least as deep as half the diameter of the reflector. The performance for such structures generally yields sidelobes of lower than -40 dB at least 10 beamwidths from the pointing angle and sidelobes of lower than -50 dB at least 20 beamwidths from the pointing angles[2,3,&4]. For a typical TST terminal with antenna size of 30 cm the -40 dB and -50 dB sidelobe zones are beyond 23° and 46° from boresight, respectively, and for a small TST with a 16 cm antenna diameter it is beyond 46° and 92° from boresight, respectively. Therefore, with TST pointing above 40° only sidelobes of -40 dB can be achieved.

In any event, reflector systems are not a practical choice. It would require two such antennas to achieve the fast hand-off as the terminal switches from one satellite to another. This hand-off requires the antenna pointing at one satellite to move from a position +50° off axis to a position -50° off axis in less than 200 μsec. A single mechanically driven reflector could not respond this quickly.

In order to achieve the fast hand-off between satellites, TSTs use phased array antennas. Dienes states that "On a phased array the improvement **may be** limited to -20 - 25 dB." (emphasis added). This implies that sidelobes 30° from the axis would be on the order of -55 to -60 dB and that sidelobes beyond 50° would be lower than -60 to -65 dB.

To achieve a reasonable price for the ground terminals, The phase array antenna specification for TST allows for phase errors of as much as 5° and amplitude errors of as much as 0.5 dB. However, the antenna sidelobe levels stated by Dienes would require tolerances of much less than 1° of phase error and 0.1 dB in amplitude error.

For example, if a 100 element phase array antenna, pointing broadside, is used, then a sidelobe level of -40 dB would be degraded to -37 dB at least 10 percent of the time for an RMS phase error of 1.4° with an RMS amplitude error of 0.2 dB[5]. Even if the theoretical array performance had no sidelobes at all, the sidelobe level would exceed -47.7 dB at least 10 percent of the time.

The assumed phased error of 1.4° corresponds to an equivalent path length error of 0.002 inches RMS, including all components in each element path. This path typically contains the manifold contribution, as well as, contributions from a variable antenuator, a phase shifter and the final power amplifier output. Such a tolerance level is not achievable in practice. Even if it were, the resultant sidelobes far exceed those suggested by Dienes.

furthermore, it is unlikely that the array surface could be maintained physically clean enough in actual operation to achieve this performance even if the tolerances were achieved. Such tight tolerances would easily increase the cost of the terminals by several multiples.

The problem becomes far more difficult when the phased array antenna is scanned ±50° from the axis. Now mutual coupling effects enter the picture as do the effects of element amplitude pattern shaping. This latter shaping refers to the fact that the element beam peak points in a direction normal to the array surface and would be at least 3 dB lower at 50° from broadside. Achieving the stated -40 dB values that Teledesic proposes will be very difficult at this scan angle. Any improvement for scan angles of 50° from the axis is not possible and has not been demonstrated. Furthermore, in the most critical case, when the terminal is pointing 50° from the axis, no improvement beyond that proposed by Teledesic is possible.

In summary, phased array solutions or their lens equivalents represent the only feasible approach for low cost ground terminals for Teledesic Network. The improvements cited by Dienes may be only theoretical and cannot be achieved in practice.

References

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2 "The Tunnel Antenna", Paul F. Von Handel, Holloman Air Development Center. Holloman AFB, Nov. 1955

3 "Experimental Investigation of Antenna Side Lobe Reduction using Tunnel Techniques". ASTIA Document No. AD117055, AFCRC-TN-57-361

4 "Low Sidelobe Reflector Antennas", H.E. Schrank, Advisory Engineer, Westinghouse - Systems Development Division, Baltimore, Maryland, IEEE Antennas and Propagation Society Newsletter, April 1985, pg. 7

5 "Array Sidelobes, Error Tolerance, Gain and Beamwidth", James K- Hsiao, Electromagnetic Branch Radar Division, September 28, 1 994, Naval Research Laboratory, Washington, DC.